Ground Based Observation of Isotopic Oxygen in the Martian Atmosphere Using Infrared Heterodyne Spectroscopy .

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Introduction: Infrared heterodyne spectra of isotopic CO_2 in the Martian atmosphere were obtained using the Goddard Heterodyne Instrument for Planetary Wind and Composition, HIPWAC, which was interfaced with the 3-meter telescope at the NASA Infrared Telescope Facility. Spectra were collected at a resolution of $\lambda/\Delta\lambda=10^7$.Absorption features of the CO_2 isotopologues have been identified from which isotopic ratios of oxygen have been determined. The isotopic ratios $^{17}O/^{16}O$ and $^{18}O/^{16}O$ in the Martian atmosphere can be related to Martian atmospheric evolution and can be compared to isotopic ratios of oxygen in the Earth's atmosphere. Isotopic carbon and oxygen are important constraints on any theory for the erosion of the Martian primordial atmosphere and the interaction between the atmosphere and surface or subsurface chemical reservoirs.

This investigation explored the present abundance of the stable isotopes of oxygen in Mars' atmospheric carbon dioxide by measuring rovibrational line absorption in isotopic species of CO_2 using groundbased infrared heterodyne spectroscopy in the vicinity of the 9.6 μm and 10.6 μm CO_2 lasing bands. The target transitions during this observation were $^{18}O^{12}C^{16}O$ as well as $^{17}O^{12}C^{16}O$ and $^{16}O^{13}C^{16}O$ at higher resolving power of $\lambda/\Delta\lambda=10^7$ and with high signal-to-noise ratio (longer integration time) in order to fully characterize the absorption line profiles. The fully-resolved lineshape of both the strong normal-isotope and the weak isotopic CO_2 lines were measured simultaneously in a single spectrum, Figure 1.

The principal sources of information on isotope abundances in the Martian atmosphere are the *Viking* Lander mass spectrometer measurements and laboratory measurements of Mars-derived meteorites, supplemented by ground based spectroscopy. The *Viking* measurements were of relatively low precision, ~5% uncertainty, thus setting a goal for the present research of ~2% accuracy in the $^{16}O/^{18}O$ and $^{12}C/^{13}C$ ratios in order to improve upon the earlier work. *Viking* measurements do not report the $^{16}O/^{17}O$ ratio. The *Viking* measurement of $^{16}O/^{18}O = 500\pm25$ [1] is

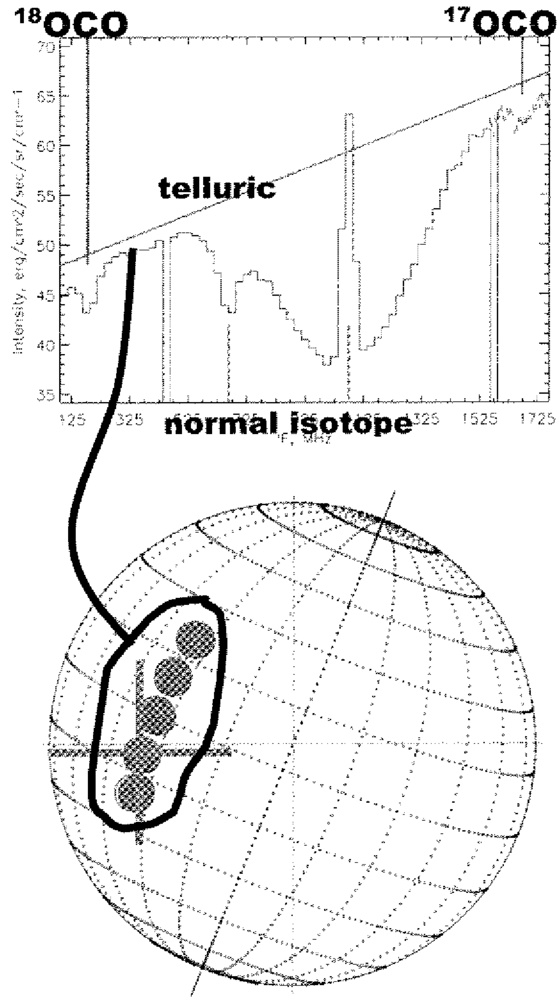

Figure 1: IR Spectra of Carbon Dioxide Isotopologues In the Martian Atmosphere.

within the measurement uncertainty of the terrestrial ratio of 489, yielding a possible slight deficit, $d^{18}O = -22\pm49‰$, for Mars relative to terrestrial. *Viking* measured $^{12}C/^{13}C = 90\pm5$, within measurement uncertainty of the terrestrial value of 89, yielding $d^{13}C = -11\pm55‰$ for Mars relative to terrestrial. The measurement uncertainties allow considerable leeway for values that differ significantly from the terrestrial standard; however, an exact recovery of terrestrial standard values would be just as important as a verified distinction from terrestrial in constraining evolutionary processes in Mars' atmosphere, as the Earth has also undergone isotopic fractionation process.

Isotopic composition is an indicator for atmospheric evolution and volatile history. Earth-like concentration of C and O isotopes in the Martian atmosphere is inconsistent with hydrogen, nitrogen, and argon, which are enhanced in heavier isotopes consistent with loss of 90% or more of Mars' initial volatile inventory , [2] and [3]. Water and CO_2 are the main H, C, and O atmospheric species. Reservoirs may be frozen in the polar caps, sequestered in rocks, or adsorbed into the regolith [4], replenishing the atmosphere and diluting isotopic enhancement. Such a model fails to explain why $^{18,17}O$ are not enhanced, while D/H is. Precise isotope ratios for C and O can discriminate models for interaction between surface reservoirs and the atmosphere [5].

Laboratory spectra of CO_2 with an appropriate isotopic mixture will be the next step in order to refine the spectroscopic parameters necessary to the retrieval of isotope ratios in the atmosphere of Mars from the ground based observations.

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